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THE IRON CONTENT OF VEGETABLES AND FRUITS

By

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INTRODUCTION

Few systematic studies of the iron content of our common vegetables and fruits have been made. In 1907 the United States Department of Agriculture (*14*) [2] published figures obtained in connection with metabolism experiments and an experimental dietary study, and included a few data taken from the earlier literature. Further figures have been presented by Sherman (*15*). They are mainly the results of previously unpublished analyses made in his laboratories, but in some cases they are averages which include data published or quoted in his earlier publications. In 1928 Peterson and Elvehjem (*12*) reported figures for a wide variety of food materials, including many vegetables and fruits. Scattered in the literature are a few further data on the iron content of vegetables which appear to be reliable. Some of these refer to products grown in specified localities; others were secured in connection with studies of the losses of mineral elements in cookery or in connection with studies of nutritional anemia.

For normal nutrition the food must supply iron in generous amounts, together with all other elements or substances which are needed for the assimilation of iron and for the construction of the complex iron containing body substances. As an essential constituent of hemoglobin, and also in other forms, iron is intimately concerned with metabolic processes controlling life and development.

It has frequently been pointed out that the liberal use of vegetables and fruits notably increases the iron content of a diet in forms which appear to be readily utilized, without significantly increasing its protein or fuel value. But in the light of their analytical results Peterson and Elvehjem (*12*) questioned whether the value of vegetables and fruits as sources of food iron has generally been fully appreciated. In as much as these food materials are gradually assuming greater prominence in American diets, and as the data regarding their iron

[1] The analyses reported in this circular, unless otherwise indicated, were made by the author in 1929 in the department of chemistry of Columbia University where she was then research assistant in food chemistry. Grateful acknowledgment is made to H. C. Sherman, who suggested and directed this research.

[2] Italic numbers in parentheses refer to Literature Cited, p. 19.

value were few, the analysis of a large variety of common vegetables and fruits was undertaken.

This circular presents the results of the author's analyses of 237 specimens of 82 different forms, parts, or varieties of vegetables and fruits, and also data from the literature which appear trustworthy and representative. In presenting other data for purposes of comparison and compilation, the author has included figures only when it was apparent from the reports that the determination of iron was the major concern of the analyst and that the work was conducted under laboratory conditions adapted to precise iron determinations.

METHOD OF ANALYSIS

The technique of iron determination is exacting, and many of the errors frequently attending the analysis lead to an overestimation of the quantities present. Contamination of the samples with iron is often a large source of error, as was emphasized by Bunge (*4*) many years ago. All the analyses made by the author were conducted in a new and specially equipped laboratory containing practically no iron fixtures or apparatus. Special care was exercised to prevent contamination of the samples. The laboratory was kept as free as possible from dust and currents of air, since laboratory dust is likely to be very rich in iron. Only instruments and vessels made of silver, nickel, platinum, silica, or glass, and thoroughly cleansed immediately before being used, were used in contact with the samples.

Approximately 50 grams of the fresh edible portion of each food material was ashed without preliminary drying, at low red heat in platinum or new silica dishes. Extraction was made when necessary with hydrochloric or acetic acid to facilitate the access of air to the last traces of carbon. Special care was taken to guard against excessive temperatures in ashing which might permit volatilization of iron as ferric chloride. Precautions were also taken to prevent contamination with iron from dust, and to prevent the inclusion of minute amounts of platinum salts from the dishes used in burning the samples.

The ash was dissolved in hydrochloric acid and the iron determined by the Zimmermann-Reinhardt method, essentially as described by Fales (*8*). Since the samples contained but small amounts of iron, and the quantities of reagents used were small, the final titration with a very dilute standardized solution of potassium permanganate was carried out in a correspondingly small final volume (about 50 cubic centimeters). The amount of permanganate required to oxidize any traces of iron in the reagents, together with that required to give a perceptible end point in the titration was determined, and allowed for in the calculation of the result of each analysis. Each specimen was analyzed in duplicate or in triplicate.

The Zimmermann-Reinhardt method is rapid but requires considerable care and some experience in manipulation. It is convenient for use in analyzing the ash of vegetables and fruits in that the reduction and titration of iron are made in the presence of hydrochloric acid. The methods used by other investigators for determining iron can be learned from the references cited, except for that of Sheets, who employed the method of Kennedy (*11*) modified to correct for the variability in the acidity of solutions of oxidized products.

The figures reported in this circular represent the percentage of iron in the edible portion of fresh products of normal appearance. When values for moisture were included with the analytical results reported in the literature, they are presented in Table 1. For specimens having an unusual percentage of moisture and for data expressed as the percentage of iron in dry matter, the results were recalculated as percentage of iron in products of average water content. In such cases the average moisture figures used in calculations are presented in the table. Figures on the average moisture content of fresh fruits and vegetables were taken from tables of proximate composition compiled in this bureau (*5*, *6*). An average moisture content of 25 per cent was assumed for dried apricots, figs, peaches, and prunes, and of 20 per cent for other dried fruits.

SELECTION AND PREPARATION OF SAMPLES

The specimens selected for analysis were purchased in the open markets of New York City, and doubtless were grown in widely varied regions. In all cases they were fresh turgid products of excellent quality.

Unless otherwise stated, only the edible portion prepared as for table use was analyzed. Products which are usually decorticated were carefully washed and dried quickly by absorbing the water with filter paper or a clean towel. The product was then pared, scraped, or skinned, and the sample weighed and ashed without further handling. When there was no definite part of the product to be discarded, as skin, seeds, or base of leaf stalk, specimens were selected for analysis only if they looked perfectly clean and were in good condition. In such cases, the sample was weighed, carefully washed several times in tap water, and repeatedly rinsed with distilled water, care being taken not to lose particles. The material was then ashed without drying.

In all cases in which the unit was too large to be analyzed as a whole, as in potatoes, a representative sample was taken.

DESCRIPTION OF SAMPLES

Apples.—Sample No. 1 was from a Winesap apple and No. 2 from a firm-fleshed apple, red in color, streaked with yellow, believed to be a Rome Beauty. Each of these was purchased in April. Sample No. 3 was from a Greening purchased in October. The fruit was thinly pared and cored in preparation for sampling. The apples analyzed by Peterson and Elvehjem (*12*) represented four varieties—Duchess (Oldenburg), Greening, Yellow Transparent, and Snow (Fameuse).

Apricots.—Samples Nos. 4 and 5 included dried fruit with apparently an average moisture content. The fruit was purchased in bulk in January and May. Sample No. 6 was a fresh fruit purchased in July. It was analyzed with skin but without the pit.

Artichokes.—Samples Nos. 7 and 8 represented the whole head. Sample No. 9 included only the tender portion usually eaten, removed from the base of each leaf.

Asparagus.—Sample No. 10 represented a thin-stalk variety, quite green in color; sample No. 11, a thick-stalked variety. The butt ends were removed in preparation for sampling. Both samples were purchased in April.

Avocados.—Samples Nos. 12 and 14 represented fruits with flesh of yellow color; sample No. 13, a fruit green in color throughout. The skins and seeds were removed before sampling.

Bananas.—Samples Nos. 15 to 18, inclusive, represented fully ripe, peeled products. The fruit was purchased in February, April, and November.

Beans.—Samples Nos. 19 to 21, inclusive, were green, fleshy pods of the improved stringless variety, with very small seeds. The ends and strings, if any, were removed before sampling. Samples Nos. 19 and 20 were purchased in April and sample No. 21 in November. Samples Nos. 22 and 23 represented yellow, succulent pods. They were purchased at two periods in May. In samples Nos. 24 and 25 the beans were removed from cleaned pods, and were weighed and analyzed without further handling.

Beets.—Samples Nos. 26 to 29 represented pared roots 1½ to 2 inches in diameter. They were purchased in bunches with leaves attached, in January, February, April, and November. Roots and leaves were analyzed separately.

Beet tops.—Sample No. 30 consisted of the leaves and the tender portion of the leafstalk grown with the root analyzed as sample No. 28.

Blackberries.—Sample No. 31 represented large, juicy berries of excellent quality, purchased in August.

Broccoli, sprouting.—Samples Nos. 32, 33, and 37 included the flowering stalk and some small leaves. The specimens were purchased in March, May, and September. Sample No. 34 included the flowering stalk only. Sample No. 35, purchased in June, came from plants with thin, light-green stalks, delicate, pale-green leaves and greenish-yellow flowers. Sample No. 36 consisted of a heavy, flowering stalk with greenish flowers and some dark-green leaves. It was purchased in August.

Broccoli leaves.—Samples Nos. 38 and 39 were large, mature leaves grown with samples Nos. 33 and 34, respectively.

Brussels sprouts.—Sample No. 40 consisted of rather large heads with bleached leaves inside. Sample No. 41 included small heads, very green throughout. Sample No. 42 consisted of heads medium in size and less green throughout than sample No. 41.

Cabbage.—Samples Nos. 43, 44, 45, 47, 48, and 49 represented new cabbage purchased from January through April, reported to have been grown in California or Florida. Most of these specimens were of a delicate, greenish-white color. Sample No. 46 was an old bleached product, said to have been imported from Holland. Samples Nos. 50 and 51 were from new products with red pigment just under the surface of the leaves. No samples included outer leaves or core.

Carrots.—Samples Nos. 52 to 55, inclusive, represented young roots, purchased in bunches with green tops attached, in January, April, October, and November. The outer skin was removed by scraping in preparation for sampling.

Cauliflower.—Samples Nos. 56 to 59, inclusive, represented the buds and flower stalks of solid white heads purchased in January, March, and May.

Celeriac.—Sample No. 60 included the green leaves and some leafstalk. Sample No. 61 consisted of the pared root.

Celery.—Samples Nos. 62 and 63 were highly bleached stalks with some of the tender, yellow leaves of the heart.

Chard.—Sample No. 64, purchased in May, included only the leaves and no stalk or petiole.

Cherries.—Samples Nos. 65 and 66 consisted of large, dark-red, sweet cherries purchased in May. They were analyzed with skins but without pits.

Chicory.—Samples Nos. 67, 68, and 69 were purchased in April and May. The bleached leaves were analyzed.

Chives.—Sample No. 70 included the green tops only.

Corn, sweet.—Samples Nos. 71 and 72 represented the milk stage of the product. The samples consisted of the tips and pulp of the kernels.

Cranberries.—Samples Nos. 73 to 76, inclusive, were purchased in April, May, September, and November.

Cucumbers.—Samples Nos. 77 to 81 were from a large, long, smooth variety, of the type often used in salads. The specimens were said to have been produced in Cuba and Florida, and in local hothouses. They were purchased in January, February, April, and September.

Dandelions.—Samples Nos. 82 and 83 were from locally grown products purchased in late March and early April.

Dates.—These samples were from packaged goods reported to have been produced in Iraq. Sample No. 84 was a seeded fruit, purchased in January. Samples Nos. 85 and 86 were purchased with seeds in May from two different stores.

Dock.—Sample No. 87 included the leaves and the tender portion of the leafstalk.

Eggplant.—Samples Nos. 88 to 92 represented the pared product

Endive, curly.—Sample No. 93 was almost wholly bleached. Sample No. 94 was very green throughout.

Escarole.—Samples Nos. 95 and 96 were taken from specimens purchased in May and June.

Figs.—Sample No. 97 consisted of a black fruit, purchased in bulk. Sample No. 98 was taken from a packaged product said to have been grown in Smyrna. Sample No. 99 was a light-brown fruit purchased in bulk.

Finochio.—Samples Nos. 100 and 101 consisted of the bleached leafstalks. The specimens were purchased in March and May.

Grapefruit.—Samples Nos. 102 to 105, inclusive, consisted of sections of fruit from which the tough white membrane had been removed.

Grapes.—Sample No. 106 included whole Concord grapes with skin and seeds. Sample No. 107 consisted of Flame Tokay grapes with skins but without seeds. Samples Nos. 108 and 109 consisted of white seedless grapes with skins.

Kale.—Samples Nos. 110 to 112, inclusive, represented pale-green, thin-leaved products; samples Nos. 113 and 114, the dark-green products usually seen in winter markets.

Kohlrabi.—Samples Nos. 115 and 116 represented the peeled vegetable. The specimens were purchased in May and September.

Kumquats.—Sample No. 117 included the whole fruit without seeds.

Leeks.—Samples Nos. 118 and 119 included the bulb and lower portion of the leaves. Sample No. 120 included only the bulb, and sample No. 121, only the lower portion of the leaves.

Lettuce.—Samples Nos. 122 to 127 represented a bleached, tightly folded head lettuce. Samples Nos. 128 and 129 were less tightly

folded and greener products. The specimens were purchased in six different months. Samples Nos. 130 to 132 were green Romaine or Cos lettuce.

Mushrooms.—Samples Nos. 133 and 134 included products with skin and part of the stalk removed.

Muskmelon.—Sample No. 135 represented fruit with salmon-colored flesh; sample No. 136, a melon with green-colored flesh.

Mustard greens.—Samples Nos. 137, 138, and 139 represented the leaves and tender portions of the leafstalk.

Okra.—Samples Nos. 140, 141, and 142 represented the product with the stem end removed. The specimens were purchased in March, April, and November.

Onions.—Samples Nos. 143 to 149, inclusive, were taken from mature onions from which skins had been removed. The specimens were purchased between January and May. All were of the white-skinned variety except sample No. 148, which was red skinned, and sample No. 149, which was yellow skinned. Samples Nos. 150 and 151 represented the bleached stalk and bulb of young onions.

Oranges.—Samples Nos. 152 and 155 were from fruits produced in Florida. Samples Nos. 153 and 154 were California products. The white membrane between sections and the seeds were removed in the preparation of the samples.

Parsley.—Samples Nos. 156 to 160, inclusive, represented the leaves with some of the stalk of specimens purchased in February, April, September, and November.

Parsnips.—Samples Nos. 161 to 163, inclusive, represented the scraped roots of specimens secured in March, September, and November.

Peaches.—Sample No. 164 was from a dried product of apparently average moisture content, purchased in bulk. It was analyzed with skin. Sample No. 165 was from a fresh, juicy, clingstone peach with pink-white flesh, said to have been produced in Georgia. It was purchased in June. Samples Nos. 166 and 167 were from fresh, yellow-fleshed, freestone peaches purchased in August and September, respectively. The skin and pit were removed in preparation of the samples of the fresh fruit.

Pears.—Samples Nos. 168 to 171 represented the pared and cored fruit of specimens purchased in April, May, and November.

Peas.—Samples Nos. 172 and 173 were seeds removed from the pods as needed for analysis. The dried mature peas analyzed by Sherman (*14*) included a smooth variety grown in New York and a wrinkled pea grown in Michigan.

Peppers.—Sample No. 174 represented the pod of a green pepper without stem end, core, or seeds.

Persimmons.—Sample No. 175 was taken from a peeled and seeded fruit of a Japanese variety.

Pineapples.—Samples Nos. 176, 177, and 178 represented the flesh without parings or core. The specimens were purchased in March and May.

Plums.—Sample No. 179 was from a yellow-skinned fruit; sample No. 180, from a red-skinned fruit; sample No. 181, from a green Kelsey (Japanese) plum; and sample No. 182, from a blue damson. They were purchased between August 1 and the middle of November. The plums were analyzed with skins but without pits.

Potatoes.—Samples Nos. 183 and 184 were from mature Idaho baking potatoes, one purchased in January and the other in May. Sample No. 185 was from potatoes said to have been grown in Maine, and samples Nos. 186, 187, and 188 from products grown on Long Island and purchased in February, May, and September, 1929. Samples Nos. 189 and 190 were said to have been grown in Bermuda. They were purchased in February and May, respectively. Sample No. 191, purchased in May, was said to be a Florida product. In preparation for sampling, the mature potatoes were pared thinly, and the new potatoes were scraped.

Prunes.—Samples Nos. 192, 193, and 194 were domestic dried products purchased in bulk. They were large fruits of perhaps higher moisture content than average.

Radishes.—Samples Nos. 195, 196, and 197 represented a small, round, red variety. Tops and rootlets were removed in preparing specimens for analysis.

Raisins.—Samples Nos. 198 to 200 were a nationally advertised seedless variety purchased in March and in May.

Raspberries.—Sample No. 201 represented juicy red berries.

Rhubarb.—Samples Nos. 202, 205, and 206 were from specimens grown on Long Island. Samples Nos. 203 and 204 were from California products.

Rutabagas.—Samples Nos. 207 and 208 were from very large mature specimens purchased in April. They were pared before being sampled.

Spinach.—Samples Nos. 209 to 214, inclusive, represented the garden variety of spinach purchased in six different months. The leaves with some of the leafstalk were included in the samples.

Squash.—Samples Nos. 215, 216, and 218 were from the White Scallop variety (cymbling) purchased in March and April. Sample No. 217 was from a summer Crookneck with yellow flesh. It was purchased in April. Sample No. 219, purchased in May, was from a Cocozelle, a long, green-striped variety with white flesh. The skin and most of the seeds were removed in preparing samples for analysis.

Strawberries.—Samples Nos. 220 to 223, inclusive, were said to have been each grown in a different locality. They were purchased between April and June. One of the samples analyzed by Bunge (*3*) was gathered near Dorpat, the other near Basel.

Sweetpotatoes.—Samples Nos. 224, 225, and 226 were taken from mature specimens of the big-stem Jersey type, pared before being sampled for analysis.

Tomatoes.—Samples Nos. 227 to 230, inclusive, were from firm, ripe specimens, skinned before being sampled.

Turnips.—Samples Nos. 231 and 232 represented young specimens of a round, purple-top variety. The products were pared before being sampled.

Vegetable-oyster.—Sample No. 233 was taken from a pared specimen.

Water cress.—Samples Nos. 234 to 237 represented leaves and leafstalks. They were purchased in March, April, and May.

TABLE 1.—*The iron content of vegetables and fruits*

Item	Sample No.	Specimens	Water	Iron	Literature cited
		Number	*Per cent*	*Per cent*	
Apples (*Malus sylvestris*)	1	1		0.00034	
	2	1		.00029	
	3	1		.00026	
		4	85.6	[1] .00043	*12*
		1		.00030	*14*
		1		.0003	*16*
Total or average		9		.00036	
Apricots (*Prunus armeniaca*), dried	4	1		.00601	
	5	1		.00607	
		2	(25.0)	[2] .00918	*12*
Total or average		4		.00761	
Apricots, fresh	6	1		.00061	
Artichokes, Globe (*Cynara scolymus*), whole head	7	1		.00134	
	8	1		.00124	
		1	84.4	.00189	*12*
Total or average		3		.00149	
Artichokes, Globe, edible portion	9	1		.00095	
Asparagus (*Asparagus officinalis*)	10	1		.00097	
	11	1		.00110	
		1	(93.0)	[2] .00141	*9*
		1	93.2	.00055	*13*
		1	91.8	.00079	*12*
Total or average		5		.00096	
Avocados (*Persea* species)	12	1		.00057	
	13	1		.00076	
	14	1		.00037	
Total or average		3		.00057	
Bananas (*Musa sapientum*)	15	1		.00031	
	16	1		.00048	
	17	1		.00026	
	18	1		.00037	
		1	75.4	.00176	*12*
		1		.0008	*14*
		1		.0005	*16*
Total or average		7		.00064	
Beans, common or kidney (*Phaseolus vulgaris*), dried		5		[3] .0082	*2*
		1	14.2	.00952	*12*
		1	12.4	.00692	*12*
		1	11.6	.0067	*14*
		1		.0072	*15*
Total or average		9		.00793	
Beans, green, string, fresh	19	1		.00072	
	20	1		.00077	
	21	1		.00070	
		[4] 2	91.3	[5] .00086	
		4		[6] .0011	*2*
		1		.0010	*9*
		1	90.8	.00118	*13*
		7	91.4	[7] .00093	*12*
		1		.0016	*14*
		1		.0011	*15*
Total or average		20		.00098	
Beans, yellow wax	22	1		.00058	
	23	1		.00057	
Total or average		2		.00058	

[1] Maximum, 0.00061 per cent; minimum, 0.00022 per cent.
[2] Calculated to average moisture content, indicated by figures in parentheses in preceding column.
[3] Maximum, 0.0090 per cent; minimum, 0.0070 per cent.
[4] Unpublished data of Olive Sheets, Mississippi Agricultural Experiment Station.
[5] Maximum, 0.00091 per cent; minimum, 0.00081 per cent.
[6] Maximum, 0.0012 per cent; minimum, 0.0010 per cent.
[7] Maximum, 0.00119 per cent; minimum, 0.00068 per cent.

TABLE 1.—*The iron content of vegetables and fruits*—Continued

Item	Sample No.	Specimens	Water	Iron	Literature cited
		Number	*Per cent*	*Per cent*	
Beans, Lima (*Phaseolus lunatus macrocarpus*), dried		1	12.3	0.01166	*12*
		1	7.85	.0072	*14*
		[1]		.0070	*15*
Total or average		3		.00862	
Beans, Lima, fresh	24	1		.00166	
	25	1		.00163	
		[4] 3	67.2	[8] .00301	
		1		.0020	*15*
Total or average		6		.00240	
Beets (*Beta vulgaris*)	26	1		.00046	
	27	1		.00048	
	28	1		.00062	
	29	1		.00060	
		1	82.3	.00236	*12*
		1		.0006	*15*
Total or average		6		.00085	
Beet tops	30	1		.00263	
		1	87.9	.00322	*13*
		1	90.3	.00355	*12*
Total or average		3		.00313	
Blackberries (*Rubus* species)	31	1		.00114	
		1	84.1	.00100	*12*
		1		.0006	*15*
Total or average		3		.00091	
Blueberries (*Vaccinium* species)		1	(83.4)	[2] .00094	*4*
		1	(83.4)	[2] .00106	*9*
		1	81.3	.00041	*12*
Total or average		3		.00080	
Broccoli, sprouting (*Brassica oleracea botrytis*)	32	1		.00143	
	33	1		.00110	
	34	1		.00093	
	35	1		.00223	
	36	1		.00114	
	37	1		.00172	
Total or average		6		.00142	
Broccoli leaves	38	1		.00295	
	39	1		.00182	
Total or average		2		.00238	
Brussels sprouts (*Brassica oleracea gemmifera*)	40	1		.00074	
	41	1		.00102	
	42	1		.00077	
		1	87.4	.00223	*12*
		1		.0011	*15*
Total or average		5		.00117	
Cabbage (*Brassica oleracea capitata*)	43	1		.00042	
	44	1		.00047	
	45	1		.00043	
	46	1		.00042	
	47	1		.00059	
	48	1		.00038	
	49	1		.00061	
		[4] 4	90.6	[9] .00047	
		1	(92.4)	[2] .00043	*9*
		1	93.1	.00078	*13*
		20	92.6	[10] .00034	*12*
		1	91.9	.0009	*14*
		1		.0011	*15*
Total or average		35		.00043	

[2] Calculated to average moisture content, indicated by figures in parentheses in preceding column.
[4] Unpublished data of Olive Sheets, Mississippi Agricultural Experiment Station.
[8] Maximum, 0.00318 per cent; minimum, 0.00288 per cent.
[9] Maximum, 0.00057 per cent; minimum, 0.00033 per cent.
[10] Maximum, 0.00059 per cent; minimum, 0.00017 per cent.

TABLE 1.—*The iron content of vegetables and fruits*—Continued

Item	Sample No.	Specimens	Water	Iron	Literature cited
		Number	*Per cent*	*Per cent*	
Cabbage, green leaves		[4] 4	90.6	[11] 0.00079	
		1	(92.4)	[2] .00289	*4*
		1	(92.4)	[2] .00129	*8*
Total or average		6		.00122	
Cabbage, red	50	1		.00104	
	51	1		.00104	
Total or average		2		.00104	
Carrots (*Daucus carota*)	52	1		.00045	
	53	1		.00060	
	54	1		.00047	
	55	1		.00046	
		1	(88.2)	[2] .00101	*9*
		1		.00082	*13*
		1	90.1	.00107	*12*
		1		.0003	*16*
		1		.0006	*15*
Total or average		9		.00064	
Cauliflower (*Brassica oleracea botrytis*)	56	1		.00113	
	57	1		.00094	
	58	1		.00081	
	59	1		.00104	
		1	87.6	.00064	*13*
		1	91.4	.00143	*12*
		1		.0006	*16*
Total or average		7		.00094	
Celeriac leaves (*Celeri graveolens*)	60	1		.00278	
Celeriac root	61	1		.00060	
Celery stalks	62	1		.00059	
	63	1		.00081	
		1	94.0	.00077	*12*
		1		.0005	*15*
Total or average		4		.00062	
Celery cabbage		1		.00068	*13*
		1	94.3	.00057	*12*
Total or average		2		.00062	
Chard (*Beta vulgaris*)	64	1		.00275	
		1	91.5	.00402	*12*
		1		[12] (.0025)	*15*
Total or average		3		.00309	
Cherries, red (*Prunus* species)	65	1		.00034	
	66	1		.00054	
		1		.0003	*4*
		1	88.0	.00046	*12*
		1		.0004	*15*
Total or average		5		.00041	
Cherries, black		1		.0004	*4*
		1		.0014	*9*
		1	81.9	.00051	*12*
Total or average		3		.00077	
Chicory [13] (*Cichorium intybus*)	67	1		.00074	
	68	1		.00039	
	69	1		.00034	
Total or average		3		.00049	
Chives (*Allium schoenoprasum*)	70	1		.00252	
Collards (*Brassica oleracea acephala*)		[4] 6	87.4	[14] .00166	

[2] Calculated to average moisture content, indicated by figures in parentheses in preceding column.
[4] Unpublished data of Olive Sheets, Mississippi Agricultural Experiment Station.
[11] Maximum, 0.00090 per cent; minimum, 0.00059 per cent.
[12] Parentheses indicate data based in part upon assumptions.
[13] Often erroneously called "endive" or French endive.
[14] Maximum, 0.00203 per cent; minimum, 0.00132 per cent.

TABLE 1.—*The iron content of vegetables and fruits*—Continued

Item	Sample No.	Specimens	Water	Iron	Literature cited
		Number	*Per cent*	*Per cent*	
Corn, sweet (*Zea mays*)	71	1		0.00024	
	72	1		.00029	
		2	81.7	.00051	*12*
		1		.0008	*15*
Total or average		5		.00047	
Cowpeas (*Vigna sinensis*), fresh seeds		[4] 12	69.3	[15] .00254	
Cowpeas, mature, dried		[4] 1	12.4	.00787	
Cranberries (*Oxycoccos macrocarpus*)	73	1		.00052	
	74	1		.00039	
	75	1		.00017	
	76	1		.00050	
		1		.0006	*15*
Total or average		5		.00044	
Cucumbers (*Cucumis sativus*)	77	1		.00022	
	78	1		.00028	
	79	1		.00043	
	80	1		.00041	
	81	1		.00040	
		1	96.8	.00035	*12*
		1		.0002	*16*
Total or average		7		.00033	
Currants, dried [16]		1	(20.0)	[2] .00547	*12*
		1		[12] (.0025)	*15*
Total or average		2		.00399	
Currants, fresh (*Ribes* species)		2	86.8	.00070	*12*
		1		.0005	*15*
Total or average		3		.00063	
Dandelion greens (*Leontodon taraxacum*)	82	1		.00203	
	83	1		.00234	
		1	(85.8)	[2] .00203	*9*
		1	88.3	.00604	*12*
		1		.0027	*15*
Total or average		5		.00303	
Dates (*Phoenix dactylifera*), dried	84	1		.00394	
	85	1		.00302	
	86	1		.00399	
		1		.0018	4
		1	(20.0)	[2] .00559	*12*
		1		.0030	*15*
Total or average		6		.00356	
Dock or sorrel (*Rumex* species)	87	1		.00125	
		[4] 1	88.8	.00156	
Total or average		2		.00141	
Eggplant (*Solanum melongena*)	88	1		.00074	
	89	1		.00045	
	90	1		.00039	
	91	1		.00031	
	92	1		.00029	
		1	92.5	.00061	*12*
		1	93.0	.0005	*16*
Total or average		7		.00047	
Endive, curly (*Cichorium endivia*)	93	1		.00084	
	94	1		.00162	
Total or average		2		.00123	

[2] Calculated to average moisture content, indicated by figures in parentheses in preceding column.
[4] Unpublished data of Olive Sheets, Mississippi Agricultural Experiment Station.
[12] Parentheses indicate data based in part upon assumptions.
[15] Maximum, 0.00348 per cent; minimum, 0.00144 per cent.
[16] Original reports did not indicate whether samples were *Ribes* or *Vitis* species; presumably seedless raisins.

TABLE 1.—*The iron content of vegetables and fruits*—Continued

Item	Sample No.	Specimens	Water	Iron	Literature cited
		Number	*Per cent*	*Per cent*	
Escarole (*Cichorium endivia*)	95	1		0.00151	
	96	1		.00155	
Total or average		2		.00153	
Figs (*Ficus carica*), dried	97	1		.00240	
	98	1		.00218	
	99	1		.00199	
		1	(25.0)	[2].0030	*9*
		1	(25.0)	[2].00479	*12*
Total or average		5		.00287	
Finochio (*Foeniculum vulgare*)	100	1		.00043	
	101	1		.00045	
Total or average		2		.00044	
Gooseberries (*Ribes* species)		1	90.1	.00047	*12*
		1		.0005	*15*
Total or average		2		.00048	
Grapefruit (*Citrus grandis*), pulp	102	1		.00021	
	103	1		.00046	
	104	1		.00020	
	105	1		.00024	
		1	92.8	.00027	*12*
		1		.0002	*16*
		1		.0003	*15*
Total or average		7		.00027	
Grapes:					
Concord, whole	106	1		.00050	
Concord, pulp [17]		1	72.5	.00074	*12*
Do		1		.0002	*16*
Malaga		1	(81.6)	[2].00116	*4*
Do		1	79.6	.00228	*12*
Red		1	83.2	.00090	*12*
Flame Tokay, seeded	107	1		.00051	
Do		1		.0004	*16*
White, seedless	108	1		.00023	
Do	109	1		.00034	
Total or average		10		.00073	
Grapes, Concord, skin [17]		1	77.2	.00136	*12*
Kale (*Brassica oleracea acephala*)	110	1		.00196	
	111	1		.00233	
	112	1		.00158	
	113	1		.00182	
	114	1		.00158	
		6		[18].00312	*7*
Total or average		11		.00254	
Kohlrabi (*Brassica oleracea gongylodes*)	115	1		.00046	
	116	1		.00035	
		1	85.4	.00089	*13*
		2	90.7	.00068	*12*
		2		.0006	*16*
Total or average		7		.00061	
Kumquats (*Fortunella* species)	117	1		.00039	
		1	85.0	.00051	*12*
Total or average		2		.00045	
Leeks (*Allium porrum*)	118	1		.00081	
	119	1		.00048	
Total or average		2		.00065	
Leek, bulb only [19]	120	1		.00045	
Leek, leaves [19]	121	1		.00110	

[2] Calculated to average moisture content, indicated by figures in parentheses in preceding column.
[17] Presumably from same fruit.
[18] Maximum, 0.00509 per cent; minimum, 0.00107 per cent.
[19] From same plant.

TABLE 1.—*The iron content of vegetables and fruits*—Continued

Item	Sample No.	Specimens	Water	Iron	Literature cited
		Number	*Per cent*	*Per cent*	
Lemons (*Citrus limonia*), juice		1	96.0	0.00015	*12*
Lemon, peel		1	87.5	.00075	*12*
Lemon, pulp		1		.0006	*15*
Lettuce (*Lactuca sativa*), head	122	1		.00063	
	123	1		.00028	
	124	1		.00060	
	125	1		.00043	
	126	1		.00031	
	127	1		.00049	
	128	1		.00039	
	129	1		.00047	
		[4] 2	95.2	[20].00050	
		1	96.6	.00042	*12*
		1	95.2	.0003	*14*
Total or average		12		.00044	
Lettuce:					
Green leaf		1	94.4	.00187	*12*
Leaf		[4] 1	95.7	.00093	
Green leaves of head lettuce		[4] 13		[21].00099	
Romaine	130	1		.00078	
Do	131	1		.00063	
Do	132	1		.00088	
Do		[4] 1	94.8	.00111	
Total or average		19		.00100	
Mushrooms (*Agaricus campestris*)	133	1		.00055	
	134	1		.00058	
		1	(90.5)	[2].00105	*12*
Total or average		3		.00073	
Muskmelon (*Cucumis melo*)	135	1		.00033	
	136	1		.00030	
		2	90.5	.00051	*12*
		1		.0003	*15*
Total or average		5		.00039	
Mustard greens (*Brassica* species)	137	1		.00144	
	138	1		.00213	
	139	1		.00209	
		[4] 13	90.6	[22].00310	
Total or average		16		.00287	
Okra (*Hibiscus esculentus*)	140	1		.00065	
	141	1		.00086	
	142	1		.00067	
		[4] 4	89.4	[23].00055	
Total or average		7		.00063	
Onions (*Allium cepa*), mature	143	1		.00062	
	144	1		.00036	
	145	1		.00040	
	146	1		.00048	
	147	1		.00036	
	148	1		.00050	
	149	1		.00060	
		1	91.0	.00054	*13*
		1	93.7	.00030	*12*
		1		.0006	*15*
Total or average		10		.00048	

[2] Calculated to average moisture content, indicated by figures in parentheses in preceding column.
[4] Unpublished data of Olive Sheets, Mississippi Agricultural Experiment Station.
[20] Maximum, 0.00053 per cent; minimum, 0.00047 per cent.
[21] Maximum, 0.00148 per cent; minimum, 0.00075 per cent.
[22] Maximum, 0.00504 per cent; minimum, 0.00215 per cent.
[23] Maximum, 0.00060 per cent; minimum, 0.00046 per cent.

TABLE 1.—*The iron content of vegetables and fruits*—Continued

Item	Sample No.	Specimens	Water	Iron	Literature cited
		Number	*Per cent*	*Per cent*	
Onions, young, bulb	150	1		0.00035	
	151	1		.00044	
		[4] 2	90.2	[24] .00055	
Total or average		4		.00047	
Onion tops, green		[4] 2	92.6	[25] .00105	
Oranges (*Citrus sinensis*), pulp	152	1		.00073	
	153	1		.00059	
	154	1		.00038	
	155	1		.00043	
		1	87.2	.00019	*4*
		2	87.0	.00066	*12*
Total or average		7		.00052	
Orange juice		1		.00028	*12*
		1		.0002	*15*
Total or average		2		.00024	
Parsley (*Petroselinum hortense*)	156	1		.00338	
	157	1		.00304	
	158	1		.00249	
	159	1		.00540	
	160	1		.00412	
		[4] 2	87.4	[26] .00185	
		2	87.6	.01921	*12*
Total or average, omitting last item		7		.00316	
Total or average, including last item		9		.00673	
Parsnips (*Pastinaca sativa*)	161	1		.00046	
	162	1		.00078	
	163	1		.00060	
		1	75.6	.00112	*13*
		1	82.7	.00107	*12*
		1		.0006	*16*
Total or average		6		.00077	
Peaches (*Amygdalus persica*), dried	164	1		.00588	
		1	(25.0)	[2] .00726	*12*
Total or average		2		.00657	
Peaches, fresh	165	1		.00055	
	166	1		.00030	
	167	1		.00016	
		1	87.2	.00036	*12*
		1		.0003	*15*
Total or average		5		.00033	
Pears (*Pyrus communis*)	168	1		.00015	
	169	1		.00036	
	170	1		.00023	
	171	1		.00039	
		1	(82.7)	[2] .00035	*4*
		1	83.9	.00046	*12*
Total or average		6		.00032	
Peas (*Pisum sativum*), dried		1		.0060	*4*
		1		.0056	*9*
		2	10.1	[27] .0056	*14*
Total or average		4		.0057	

[2] Calculated to average moisture content, indicated by figures in parentheses in preceding column.
[4] Unpublished data of Olive Sheets, Mississippi Agricultural Experiment Station.
[24] Maximum, 0.00072 per cent; minimum, 0.00037 per cent.
[25] Maximum, 0.00114 per cent; minimum, 0.00096 per cent.
[26] Maximum, 0.00196 per cent; minimum, 0.00175 per cent.
[27] Maximum, 0.0064 per cent; minimum, 0.0048 per cent.

TABLE 1.—*The iron content of vegetables and fruits*—Continued

Item	Sample No.	Specimens	Water	Iron	Literature cited
		Number	*Per cent*	*Per cent*	
Peas, fresh	172	1	----	0.00173	----
	173	1	----	.00173	----
	----	[4] 2	76.5	[28] .00176	----
	----	4	----	[29] .0027	*2*
	----	3	75.2	.00177	*12*
	----	1	----	.0017	*15*
Total or average	----	12	----	.00207	----
Peppers (*Capsicum annuum*), green	174	1	----	.00038	----
	----	1	94.0	.00041	*12*
	----	1	----	.0004	*16*
Total or average	----	3	----	.00040	----
Peppers, red	----	1	91.7	.00060	*12*
Persimmons, Japanese (*Diospyros kaki*)	175	1	----	.00027	----
Pineapples (*Ananas sativus*)	176	1	----	.00033	----
	177	1	----	.00036	----
	178	1	----	.00033	----
	----	1	92.0	.00032	*12*
	----	1	----	.0005	*15*
Total or average	----	5	----	.00037	----
Plums (*Prunus* species)	179	1	----	.00023	----
	180	1	----	.00075	----
	181	1	----	.00027	----
	182	1	----	.00037	----
	----	1	----	.0006	*4*
	----	3	84.9	.00077	*12*
	----	1	----	.0005	*15*
Total or average	----	9	----	.00056	----
Pomegranates (*Punica granatum*)	----	1	73.5	.00117	*12*
	----	1	----	.0004	*15*
Total or average	----	2	----	.00078	----
Potatoes (*Solanum tuberosum*), mature	183	1	----	.00062	----
	184	1	----	.00062	----
	185	1	----	.00075	----
	186	1	----	.00055	----
	187	1	----	.00060	----
	188	1	----	.00071	----
	----	4	----	[30] .0011	*2*
	----	1	(77.8)	[2] .00117	*4*
	----	1	78.2	.00085	*12*
	----	2	----	.00123	*14*
Total or average	----	14	----	.00091	----
Potatoes, new	189	1	----	.00048	----
	190	1	----	.00043	----
	191	1	----	.00043	----
Total or average	----	3	----	.00045	----
Prunes (*Prunus domestica*)	192	1	----	.00144	----
	193	1	----	.00128	----
	194	1	----	.00154	----
	----	1	(25.0)	[2] .00694	*12*
	----	1	----	.0029	*14*
	----	1	----	.0030	*15*
Total or average	----	6	----	.00285	----
Pumpkin (*Cucurbita pepo*)	----	[31] 1	81.1	.00089	*12*
	----	1	91.7	.00110	*12*
	----	1	----	[12](.0008)	*15*
Total or average	----	3	----	.00093	----

[2] Calculated to average moisture content, indicated by figures in parentheses in preceding column.
[4] Unpublished data of Olive Sheets, Mississippi Agricultural Experiment Station.
[12] Parentheses indicate data based in part upon assumptions.
[28] Maximum, 0.00186 per cent; minimum, 0.00166 per cent.
[29] Maximum, 0.0030 per cent; minimum, 0.0024 per cent.
[30] Maximum, 0.0014 per cent; minimum, 0.0009 per cent.
[31] Also called Queen squash.

TABLE 1.—*The iron content of vegetables and fruits*—Continued

Item	Sample No.	Specimens	Water	Iron	Literature cited
		Number	*Per cent*	*Per cent*	
Quinces (*Cydonia oblonga*)		1	82.5	0.00101	*12*
Radishes (*Raphanus sativus*)	195	1		.00048	
	196	1		.00068	
	197	1		.00048	
		2	94.4	.00136	*12*
		1		.0006	*15*
Total or average		6		.00083	
Raisins (*Vitis vinifera*), seeded		1	(20.0)	[2].00778	*12*
		1		.0036	*14*
Total or average		2		.00569	
Raisins, seedless	198	1		.00281	
	199	1		.00240	
	200	1		.00279	
		1	(20.0)	[2].00485	*12*
		1		.0021	*15*
Total or average		5		.00299	
Raspberries (*Rubus* species)	201	1		.00116	
		1	(83.4)	[2].00061	*4*
		1	(83.4)	[2].00065	*9*
		2	84.1	.00099	*12*
Total or average		5		.00088	
Rhubarb (*Rheum rhaponticum*)	202	1		.00066	
	203	1		.00034	
	204	1		.00036	
	205	1		.00041	
	206	1		.00031	
		1		.00086	*12*
		1		.0010	*16*
Total or average		7		.00056	
Rutabagas (*Brassica campestris*)	207	1		.00026	
	208	1		.00029	
		1	90.7	.00028	*13*
		1	(89.1)	[2].00061	*12*
Total or average		4		.00036	
Spinach (*Spinacia oleracea*)	209	1		.00230	
	210	1		.00205	
	211	1		.00258	
	212	1		.00304	
	213	1		.00289	
	214	1		.00254	
		[4] 4	91.2	[32].00262	
		1	(92.7)	[2].00169	*1*
		[3] 3		[33].0026	*2*
		1	(92.7)	[2].00180	*8*
		[34] 5		[34].00272	*7*
		1	92.9	.00245	*13*
		1	(92.7)	[2].00266	*12*
		1	(92.7)	[2].00274	*14*
Total or average		23		.00255	
Squash (*Cucurbita maxima*), winter		1	90.4	.00055	
Squash, summer (*Cucurbita pepo*)	215	1		.00021	
	216	1		.00043	
	217	1		.00031	
	218	1		.00039	
	219	1		.00039	
Total or average		5		.00035	

[2] Calculated to average moisture content, indicated by figures in parentheses in preceding column.
[4] Unpublished data of Olive Sheets, Mississippi Agricultural Experiment Station.
[32] Maximum, 0.00300 per cent; minimum, 0.00242 per cent.
[33] Maximum, 0.0029 per cent; minimum, 0.0025 per cent.
[34] Maximum, 0.00309 per cent; minimum, 0.00243 per cent.

TABLE 1.—*The iron content of vegetables and fruits*—Continued

Item	Sample No.	Specimens	Water	Iron	Literature cited
		Number	*Per cent*	*Per cent*	
Strawberries (*Fragaria* species)	220	1		0.00061	
	221	1		.00069	
	222	1		.00043	
	223	1		.00049	
		2	(90.0)	[2] .00089	*3*
		2	90.3	.00066	*12*
		1		.0008	*15*
Total or average		9		.00068	
Sweetpotatoes (*Ipomoea batatas*)	224	1		.00047	
	225	1		.00074	
	226	1		.00056	
		[4] 5	69.5	[35] .00083	
		1		.00171	*13*
		1	72.1	.00092	*12*
		2		.0005	*14*
		1		.0005	*16*
Total or average		13		.00077	
Tangerines (*Citrus nobilis*), pulp		1	86.0	.00061	*12*
Tomatoes (*Lycopersicon esculentum*)	227	1		.00039	
	228	1		.00048	
	229	1		.00051	
	230	1		.00031	
		1	94.2	.00060	*12*
		1	95.0	.0004	*14*
		1		.0004	*15*
Total or average		7		.00044	
Turnips (*Brassica rapa*), root	231	1		.00035	
	232	1		.00040	
		[4] 5	92.8	[36] .00052	
		1	91.5	.00070	*12*
		1	92.0	.0006	*14*
		1		.0005	*15*
Total or average		10		.00052	
Turnip tops		[4] 6	89.5	[37] .00414	
		5		[38] .00269	*7*
Total or average		11		.00348	
Vegetable-oyster or salsify (*Tragopogon porrifolius*)	233	1		.00196	
		1	76.5	.00124	*12*
Total or average		2		.00160	
Water cress (*Sisymbrium nasturtium-aquaticum*)	234	1		.00124	
	235	1		.00274	
	236	1		.00271	
	237	1		.00200	
		1	92.5	.00721	*12*
		1		.0019	*15*
Total or average		6		.00297	
Watermelon (*Citrullis vulgaris*)		1	92.7	.00023	*12*

[2] Calculated to average moisture content, indicated by figures in parentheses in preceding column.
[4] Unpublished data of Olive Sheets, Mississippi Agricultural Experiment Station.
[35] Maximum, 0.00100 per cent; minimum, 0.00068 per cent.
[36] Maximum, 0.00060 per cent; minimum, 0.00043 per cent.
[37] Maximum, 0.00724 per cent; minimum, 0.00235 per cent.
[38] Maximum, 0.00287 per cent; minimum, 0.00255 per cent.

DISCUSSION OF RESULTS

Data are presented in this circular on the iron content of 110 different forms, parts, or varieties of fruits and vegetables, for 82 of which some analyses were made by the author. Twelve of the 110 averages represent dried or mature plant products, and 98 refer to fresh, succulent, or immature plant products.

The fresh or succulent vegetables and fruits may be divided into four groups on the basis of their iron content. For purposes of this classification those containing less than 0.00040 per cent of iron were considered relatively poor sources of iron; those containing from 0.00040 to 0.00079 per cent, fair; those containing from 0.00080 to 0.00159 per cent, good; and those containing 0.00160 per cent or more, excellent. According to this rather arbitrary division 13 of the 98 fresh vegetables and fruits may be classified as poor, 44 as fair, 24 as good, and 17 as excellent sources of food iron. The details are shown in the summary in Table 2.

TABLE 2.—*Fresh vegetables and fruits classified as sources of iron*

POOR (IRON CONTENT LESS THAN 0.00040 PER CENT)

Apples.	Muskmelon.	Pears.	Rutabagas.
Cucumbers.	Orange juice.	Persimmons, Japanese.	Squash, summer.
Grapefruit.	Peaches.	Pineapples.	Watermelon.
Lemon juice.			

FAIR (IRON CONTENT FROM 0.00040 TO 0.00079 PER CENT)

Apricots.	Cranberries.	Lettuce, head.	Potatoes, new.
Avocados.	Currants.	Mushrooms.	Rhubarb.
Bananas.	Eggplant.	Okra.	Squash, winter.
Beans, yellow wax.	Finochio.	Onions, mature.	Strawberries.
Cabbage.	Gooseberries.	Onions, young.	Sweet corn.
Carrots.	Grapes.	Oranges.	Sweetpotatoes.
Celeriac (root).	Kohlrabi.	Parsnips.	Tangerines.
Celery cabbage.	Kumquats.	Peppers, green.	Tomatoes.
Celery stalk.	Leeks.	Peppers, red.	Turnips.
Cherries, black.	Leek bulbs.	Plums.	
Cherries, red.	Lemon peel.	Pomegranates.	
Chicory.	Lemon pulp.		

GOOD (IRON CONTENT FROM 0.00080 TO 0.00159 PER CENT)

Artichokes, leaf base.	Blueberries.	Dock or sorrel.	Onion tops.
Artichokes, whole head.	Broccoli, sprouting.	Endive, partly green.	Pumpkin.
Asparagus.	Brussels sprouts.	Escarole.	Potatoes.
Beans, green, string.	Cabbage, green.	Grape skin, Concord.	Quinces.
Beets.	Cabbage, red.	Leek leaves.	Radishes.
Blackberries.	Cauliflower.	Lettuce, green.	Raspberries.

EXCELLENT (IRON CONTENT 0.00160 PER CENT OR MORE)

Beans, Lima.	Chives.	Kale.	Spinach.
Beet tops.	Collards.	Mustard greens.	Turnip tops.
Broccoli leaves.	Cowpeas.	Parsley.	Vegetable-oyster.
Celeriac leaves.	Dandelion greens.	Peas, English, garden.	Water cress.
Chard.			

The group considered relatively poor sources of iron consists almost entirely of fruits and fruit juices. Approximately half of the group called fair consists of fruits; the rest comprise seed pods, blanched leaves, blanched leafstalks, roots, and bulbs. Of chief importance in the group designated as good sources are potatoes and thick pigmented stalks and leaves. In the group called excellent sources of iron are the immature seeds of leguminous plants and thin green leaves. The latter are conspicuous for their iron value.

This classification shows, as has often been observed, that much of the iron in plant tissue is associated with the chlorophyll. The distribution of iron in plant tissue has also been related by Ingalls

and Shive (*10*) to the hydrogen-ion concentration of the tissue fluids. Both chlorophyll synthesis and the hydrogen-ion concentration of plant-tissue fluids appear to be affected by soil and climatic conditions. Variations in such environmental factors are probably responsible in part for the variations observed in the percentage of iron in any one variety, part, or form of vegetable or fruit. Deviations from the average moisture content also affect the apparent iron value of any given specimen. As a class, however, the green-colored vegetables are of great importance for their iron content and for many other nutritive values as well. With a view to improving American diets, the more liberal use of them may well be encouraged.

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